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NEW METHODS IN THE STUDY OF STELLAR SPECTRA[1]

By DR. OTTO STRUVE

YERKES OBSERVATORY, UNIVERSITY OF CHICAGO, AND MCDONALD OBSERVATORY, UNIVERSITY OF TEXAS

THIS year marks the one hundredth anniversary of one of the greatest contributions to astronomy: In 1844 Bessel published a paper on the *Astronomische Nachrichten* in which he showed that the slow angular proper motions of Procyon and Sirius are slightly irregular and that in the case of Sirius the departures of the observations from uniform, rectilinear motion are suggestive of a period of fifty years. Eighteen years later Alvan G. Clark discovered a faint companion to Sirius in the place predicted by Bessel's successors. The period of this companion, according to a recent orbit by Volet, is 49.94 years—almost precisely the value deduced by Bessel. The extraordinary physical character of the companion of Sirius—the first white dwarf known to astronomers—has been the subject of many recent investigations on the structure of the stars and on the properties of matter in the degenerate state. These remarkable advances in physical science were possible because Sirius is not a single star, but is a binary pair in which the brilliant primary serves as an indicator of the distance, size and mass of the system. The fundamental contribution by Bessel consisted in the use of a new method: The proper motions were used to reveal the existence of an invisible (until then) companion.

It is appropriate that in view of this anniversary I should devote my address to a description of several new methods which have been of help in our investigations of double stars. We are no longer dependent solely upon visual observations of wide pairs which can be resolved in our telescopes or upon accurate proper motions to infer the existence of invisible companions. Photometric measurements of the brightnesses of certain stars show periodic oscillations which can only be explained if we assume that in a close unresolved pair the plane of the orbit lies in the line of sight and that each component eclipses the other once

[1] Address of the retiring vice-president and chairman of Section D of the American Association for the Advancement of Science (1943).

in every revolution. An even more powerful tool is the spectrograph which permits us to measure the Doppler displacements of the spectral lines and to determine whether these displacements are constant or variable. If they are variable and periodic the presumption is great that we are observing a binary whose velocity component in the line of sight reflects the direction and the speed of the star in its orbit. About one thousand eclipsing variables have been discovered and their periods and minima of light determined. For nearly four hundred stars the spectrographic orbits have been determined. But only about sixty stars are common to the two lists. Every eclipsing variable must, of course, be a spectroscopic binary, but only those spectroscopic binaries whose inclinations are sufficiently close to 90° are eclipsing variables.

On June 23, 1880, Professor V. K. Ceraski, director of the University Observatory at Moscow, Russia, noticed that an inconspicuous star in the constellation Cepheus was very much fainter than on several preceding nights. He noted it as a variable star and soon established that the variation in light repeated itself every two and one-half days. In conformity with the usual practice the star was designated by a capital letter of the Roman alphabet and it is now known as U Cephei. During the past sixty-four years a large number of visual and photographic observations of the light curve have been made at various observatories. The star is of the eclipsing type: The partial phase, when the disc of the larger but fainter star gradually encroaches upon the brilliant disc of the smaller star, lasts about four and one-half hours. During this interval the brightness of the star is reduced to about one tenth of its normal value. The drop in brightness is especially rapid in the later stages of partial eclipse, and it is thrilling to see the light going out as one observes U Cephei in a small telescope. During totality, which lasts two hours, the light comes entirely from the dim and yellow companion. Then during another four and one-half hours the disc of the bluish primary is gradually uncovered and eleven hours after the beginning of the eclipse the light is normal. Thereafter, for forty-nine hours, the light undergoes only minor fluctuations. In particular, when the brilliant primary is in front of the dim companion the total light is reduced by less than one tenth of its normal value. In fact, the depth of the principal eclipse is roughly one hundred times greater than the depth of the secondary eclipse.

In spite of this disparity both eclipses have been observed by a number of competent observers among whom the late Professor R. S. Dugan, of Princeton, and Professor R. H. Baker, of Illinois, deserve special credit. The secondary eclipse occurs almost precisely half-way between two primary eclipses. This information is important. It tells us that the orbit of U Cephei is either circular, so that the motions of the stars are uniform, or if it should be elliptical the periastron must be either at its nearest or its most distant point from the earth. We describe this condition by saying that the product e.cos ω of the eccentricity times the cosine of the angle which measures the longitude of the periastron is close to zero. The photometric observations do suggest a small departure from zero, but this departure is only consistent with a value of the eccentricity not larger than 0.08.

The spectrographic orbit of U Cephei was determined in 1930 by Professor E. F. Carpenter, of Arizona, from photographs taken at the Lick Observatory. The Doppler displacements turned out to be periodic, as they should in a binary, but the shape of the resulting orbit was very unsymmetrical. The eccentricity was almost 0.5 and the periastron occurred near the ascending node of the orbit, that is, about 90° from the nearest point and 90° from the most distant point in the orbit. The angle ω is measured from the node, not from the nearest point of the orbit. Hence, ω was close to 0° and cos ω = 1. The spectroscopically determined value of e.cos ω was, therefore, almost 0.5—completely at variance from the photometric value.

This discrepancy has worried astronomers for the past fourteen years. No one knew whether Carpenter's results were correct, but every one agreed that the photometric observations could not be in error. Unfortunately, there are in existence only half a dozen spectrographs, at the most, which are sufficiently powerful to record the spectrum of U Cephei with sufficient dispersion to analyze and measure its absorption lines and most of these are overburdened with work. Yet, the question is a rather important one: If we can not trust the spectrographic orbit of U Cephei, how can we be sure that other spectrographic orbits give us the true elements of the hundreds of binaries for which they have been determined?

I have recently obtained a long series of spectrograms of U Cephei at the McDonald Observatory in Texas. The spectrum is that of a star whose temperature is about 18,000° C. and whose spectral lines are very diffuse and shallow. We associate this appearance of the lines with rapid axial rotation of the star; and by comparing its lines with those of other stars we infer that the primary component of U Cephei rotates with a velocity at the equator of about 200 km/sec. This is about one hundred times faster than the rotational velocity of the sun, but it is not unusual among the hotter stars. The spectrum of the secondary component is too faint to be photographed except with the long exposures which are necessary

during totality. These long exposures show a spectrum of the solar type, characterized by a temperature of about 5,000° C. The lines of this star are sharp and the equatorial velocity of its rotation is less than 50 km/sec.

Now, the photometric observations give us the ratio of the radii of the two components. This quantity is derived in a very simple manner from the durations of the partial and total phases of the eclipses, and it is one of the most reliable results of the photometric analysis. The observations show unmistakably that the hot star has about one half the size of the cooler star. Yet it rotates more than four times faster. Clearly, the periods of rotation of the two stars are not the same and at least one of these can not be synchronized with the period of revolution of the binary. This is a most extraordinary result which no one had expected: The components are quite close to one another; their surfaces are separated by less than one radius of the larger component. It had usually been thought that in such a close binary pair the periods of rotation and of revolution must coincide and, if they do not, the system will rapidly follow the theoretical scheme of binary evolution with a gradual approach toward synchronization. As a matter of fact, the great majority of spectroscopic binaries do show strong evidence of synchronization, and U Cephei is definitely abnormal.

The velocity curve which I derived from my measures of U Cephei shows another effect of rapid rotation. In the two partial phases of the eclipse, when the disc of the primary is partly covered by the darker disc of the secondary, the lines of the primary are unsymmetrically displaced: Just before totality we observe the receding limb of the primary; immediately after totality we observe the approaching limb. This phenomenon had been previously observed in other stars. But I was not prepared to find that in U Cephei this effect completely distorts the descending branch of the velocity curve, so much so, in fact, that it is difficult to derive reliable elements of the spectrographic orbit.

Nevertheless, I believe that my observations conclusively show that the spectrographic observations are not consistent with the photometric results: The velocity curve is unsymmetrical in the sense found by Carpenter, although the degree of asymmetry is less than was found by him. What, then, is the cause of the discrepancy?

When I carefully examined the spectral lines of U Cephei during the partial phase I noticed that the hydrogen lines looked very unsymmetrical: Before totality they seemed to possess a narrow and well-defined core to the violet of the center and after totality they had a much stronger and broader core to the red of the center of the line. I at first thought that this asymmetry was produced by the Schlesinger-Rossiter-McLaughlin rotation effect, but a more careful study of the theoretical line contours convinced me that in U Cephei the asymmetry would be least just before and after totality, while the opposite was observed on my plates. I decided that the narrow cores before totality and the broader cores after totality must come from two streams of gas; the one receding, the other approaching. The cores gave no indication of Stark effect broadening. Hence, I believe, the streams have very low pressures. They can not be simply the atmospheric limbs of the eclipsing secondary because their displacements are too large to accord with the small rotational velocity of the secondary. It is most probable that the streams flow from the cool star toward the hot star, and from the hot star toward the cool star. In other words, the observations suggest that the two stars are not completely separated, but are joined by a tenuous common atmosphere in which currents may be set up in a manner analogous to those investigated theoretically by Kuiper and observationally by me in the famous binary system of β Lyrae.

It is perhaps not unreasonable to suppose that if gaseous currents can distort the spectral lines in the partial phases of the eclipse, they may do so outside of eclipse, and thereby render the descending branch of the velocity curve steeper than the ascending branch.

In U Cephei this hypothesis remains without confirmation. It is a possibility, but we lack other observational data to verify it. We, therefore, turn our attention to another remarkable eclipsing variable, SX Cassiopeiae. This binary consists of a small, hot primary and a large, cool and dim secondary. The period is 36 days and the secondary eclipse is exactly halfway between successive principal eclipses. Photometrically $e \cos \omega = 0$. The spectra secured at the McDonald Observatory show $e = 0.5$, $\omega = 10°$, so that approximately $e \cos \omega = 0.5$. The results are incompatible and we have precisely the same situation as in U Cephei.

But SX Cassiopeiae shows in its spectrum a series of emission lines of hydrogen and other elements. Such lines are not present in U Cephei because the size of the latter's system is much smaller than that of SX Cassiopeiae, and the intensity of an emission line depends upon that part of the volume filled with gas, which is not projected upon the apparent disc of either component star, as seen from the earth. The emission lines are double, showing that there exist two streams of nebulous matter, one receding, the other approaching. Before totality the violet emission lines become weaker, while after totality the red emission lines become weaker. This undoubtedly rep-

resents the eclipse of an approaching stream before totality and of a receding stream after totality. The existence of the streams is proved beyond doubt; they flow from the cool star along the following side of the hot star and return along its preceding side, after making a complete circuit.

The interesting thing about SX Cassiopeiae is that we can actually link these streams with the anomalous velocity curve and attribute to the streams the distortion of the spectral lines which makes the velocity curve unsymmetrical and appears to give us a large eccentricity. We are making use here of a very new and interesting tool of astrophysical research, which has already produced valuable results in a number of problems. This tool is designated as the dilution effect. It permits us to determine whether an absorbing mass of gas is on the surface of a star, or at some distance above the surface. The relative intensities of certain spectral lines—Mg II, Si II and He I—in a source whose dilution we wish to determine are compared with those produced in an ordinary stellar atmosphere. The ratio of the total intensities is inversely proportional to the square of the height of the source above the photosphere of the star. In SX Cassiopeiae the dilution test showed that at the time of secondary eclipse we are observing not the pure, undisturbed spectrum of the hot star, in front of the cool star, but a composite spectrum consisting in part of lines produced in an approaching stream—that is, in a stream receding from the hot star—at a considerable height above the photosphere. The measured radial velocities were not those of the hot star alone but were in part those of the moving stream. The velocity curve, in consequence, was greatly distorted and did not represent the orbit of the binary system.

The advances which I have described were possible because we had at our disposal two new methods: the method of stellar rotation and the method of the dilution effect. When a star rotates as a solid body (which it probably does not, though the approximation may be good enough for most purposes) around a fixed axis, all points on the apparent disc which are located at the same distance from the projection of the axis have the same radial component of rotational velocity. The broadened spectral line, therefore, serves in the nature of a spectroheliograph: Each point on the line-profile comes from a definite vertical strip on the disc of the star. If the star's atmosphere is not everywhere the same, in temperature or density, the shape of the broadened line should reveal the difference. An effect of this kind has been observed in U Cephei. The spectral lines of U Cephei prior to totality are systematically weaker than after totality. This must mean that the receding half of the star as seen at principal eclipse has weaker lines than the approaching side. We already know that the hot companion of U Cephei rotates very rapidly. Hence (as was long ago suggested by Dugan from photometric inequalities in the light curve) the tidal bulge of the star may be carried forward by the rotation and is seen before totality. We do not know why the lines originating above the bulge are weaker than those coming from other parts of the star's atmosphere. But we have isolated an interesting astrophysical phenomenon and made it susceptible of theoretical treatment.

The methods of rotation and dilution were helpful in the solution of another recent puzzle. In 1928, Dr. M. L. Humason and Dr. S. B. Nicholson of the Mount Wilson Observatory determined the period and the spectrographic elements of a new spectroscopic binary designated as HD 163181. In 1938, Dr. S. Gaposchkin at Harvard found that this star is also an eclipsing variable, the period in light agreeing exactly with the period of the spectrographic orbit. The spectrum shows absorption lines of one star only; the other component registers no absorption lines in the spectrum. The radial velocity of the brighter star is variable. As it recedes from the earth and gradually reaches the most distant point in the orbit it reaches the time of superior conjunction. At this time the star may undergo an eclipse if the inclination is suitable. Gaposchkin found two eclipses: a slightly deeper one when the star is at inferior conjunction; the secondary when it is at superior conjunction. This result appears paradoxical because the spectrographic results predict the principal eclipse at superior conjunction and also make it probable that the secondary eclipse should be very shallow.

In order to resolve this difficulty new spectrograms were obtained at the McDonald Observatory. The velocity curve clearly shows the rotation effect before and after superior conjunction. Hence, there can be no doubt that the principal star is actually eclipsed when it stands behind the secondary component.

The spectrum of HD 163181 is not especially remarkable, but it does show several points of interest. The lines of hydrogen and helium have red emission borders; these disappear or become very weak at inferior conjunction, and are relatively strong at superior conjunction. The absorption lines, on the other hand, are strengthened at inferior conjunction and are weakened at superior conjunction.

We first examine the variation of the absorption lines. The dilution effect shows at once that the absorbing gases are on the surface of a normal star; they are not produced in a nebulous shell or stream. We infer that they are weakened at superior conjunction because the primary component is then eclipsed. They are strengthened at inferior conjunction because

at that time the continuous spectrum of the eclipsed secondary component is invisible and the lines are free of blending with continuous light of the secondary. Similarly, the emission lines are strong at superior conjunction because they must belong to the secondary component and these lines are weak at inferior conjunction because at that time the secondary component is eclipsed.

The result of this study is the discovery of an unusual kind of star. The secondary component of HD 163181 has a strong continuous spectrum with weak emission lines, but without perceptible absorption lines. The interpretation of the spectrographic observations would have been easier if there had not been another complication: The emission lines of the secondary show a permanent red shift of some 100 km/sec. with respect to the absorption lines of the primary. This phenomenon had previously been found in two or three other stars, but its origin is unknown.

OBITUARY

DAVID EUGENE SMITH

(AN APPRECIATION)

IN the passing of Dr. David Eugene Smith, who died in New York on July 29, the world has lost a profound scholar and a distinguished teacher. Dr. Smith's accomplishments were so unique and varied that he not alone enriched his own life but also the lives of thousands of his pupils and admirers the world over. His life is worthy of a full volume of many pages, instead of a few pages as here permitted. Others undoubtedly will express appreciation of Dr. Smith's mathematical accomplishments in research and teaching, but this sketch will take the more special phases of his life work into consideration. He made, of course, no distinction in his life's activities; that is, he did not overemphasize one activity against the other. He was equally energetic as teacher, research worker, book collector, connoisseur of portrait prints and manuscripts, bibliographer, traveler and genial host to his many fortunate friends. If ever a man enjoyed a full life, surely Dr. Smith accomplished that.

In reviewing these many and varied activities and their results, one is sure to find only one theme or subject controlling his life. This subject was mathematics in its many ramifications. It received the full benefit of his keen analytical mind, although his method was synthetical in producing results. These results are well known to scholars, particularly in the form of books and special monographs. He may not be famous as a great mathematician in the technical aspect, but to the world of scholarship he will ever be known as the "Great Humanist in Mathematics."

May we not say, in his own words which he spoke concerning Newton at the bicentenary celebration in 1927, as chairman of the program committee and as presiding officer in the opening address: "When we review his life, his idiosyncrasies, his periods of contrast, . . . may we not take some pleasure in thinking of him as a man—a man like most other men save in one particular—he had genius—a greater touch of divinity than comes to the rest of us. Few men have ever lived who explored so successfully as wide a range of human activities and few who could so justly have used the well-known phrase, *Homo sum, et nihil humani a me alienum puto.*" Dr. Smith too had genius in a degree, though of another kind.

(a) He had capacity for friendship and hospitality.

(b) He had capacity to inspire and aid scholars.

(c) He had appreciation of the works of others.

(d) He had capacity for recognizing beauty in mathematical prints and instruments and in Oriental art books.

(e) He had capacity for organization and administration.

Dr. Smith was not a Newton scholar in the technical aspect, but a Newton in the discovery of the humanistic and in the interpretation of the very abstract thoughts of mathematics. His range was from the elementary to the advanced, for he could teach the child to understand numbers as well as discuss abstract formulas with the graduate student. The classroom was not his only sanctum for teaching; his home —his country—and in fact the world, for he lectured whenever called upon, in New York, Paris, Arabia or Yokohama.

His historical writings are authoritatively manifested in his well-known "History of Mathematics" (Vol. I, "General Survey of the History of Elementary Mathematics"; Vol. II, "Special Topics of Elementary Mathematics"). And again, a more advanced treatise was his "Source Book of Mathematics." His little volume, "History of Mathematics in America before 1900," with Dr. J. Ginsberg, will always remain a standard source book. The constant use of these source books is revealed in the teaching research in our mathematical courses. A large number of smaller books and monographs on phases of teaching and history of mathematics are listed in a very complete bibliography of Dr. Smith's writings issued in the first volume of *Osiris,* presented to him to commemorate his seventy-sixth birthday in 1936.

The culmination of his historical research and writings may properly be assigned to the public recognition accorded to his work when Dr. George Sarton presented to him at a special gathering at Columbia University on January 21, 1936, a beautifully bound volume appropriately known as a Festschrift. This Festschrift acknowledged to Dr. Smith the debt the world of learning owes him.

Intellectual insight is not all that is necessary to bring about improvement in our culture; it needs to be accompanied by the will to do, to create and to analyze the needs of the day. In the founding of the History of Science Society in 1924, Dr. Smith became the father of this cultural movement in America. The society has now become the largest and most important association of its kind in the world. The farsightedness of its founder was again revealed when in 1931 he presented to Columbia University a unique and valuable collection of rare books, manuscripts, prints, medallions and scientific instruments illustrating the history and development of mathematics. It will be evident to those who know this library that Dr. Smith kept in mind the importance of teaching as well as research, for it contains illustrated material necessary for any serious student. In this same library is the George A. Plimpton Library of rare arithmetics collected primarily by Dr. Smith for Mr. Plimpton. It is known that in the fifteenth and sixteenth centuries approximately four hundred different books were printed that may be, strictly speaking, called arithmetics. These have been preserved in this library.

The most elaborate and scholarly bibliography of arithmetic yet attempted was prepared from the Plimpton collection. This bibliography presents in upwards of five hundred pages a list of arithmetics published before 1601. It contains a complete bibliographical description, as well as a large number of illustrations, such as title pages, of most of the important arithmetics of the formative period of the modern history of the subject. This volume illustrates the keen, critical bibliographer its compiler was. The beautiful format is in keeping with all that Dr. Smith did.

As a traveler Dr. Smith supplemented and enriched the curriculum of his mathematical courses, particularly that of the history of mathematics. Undoubtedly the teaching courses received the same benefits, for such treasures as manuscripts, rare books from the Greeks or the Hindus or from the Renaissance or, more pleasing, probably those of the Arabians or Persians, and again the Chinese and the Far East are represented. The peculiar insight for anything mathematical which he must have had when traveling in foreign lands was indeed unbelievable, unless one was fortunate enough to be his student, friend or guest at his seminar or home, and there be shown his "wealth from the Indies." For years previous to his world tours he spent each year in the city of his greatest love and fascination, namely, Paris. Here he was more at home than most travelers, for he spoke French with traditional ease, and roamed its streets and sought out its historical monuments. His love for Paris and French mathematicians present and past is revealed by two publications. The first was published in 1924, "Historical-mathematical Paris," and the other "Mathematica Gothica," 1925. These two little volumes were issued as mementoes of his love for Paris and presented to his intimate friends.

Dr. Smith was virtually possessed by the search for truth and beauty in the field of mathematics, its history and teaching, so that he set no limit or expense to attain the end and the material possession of the object. As a result, his own researches have attained the greatest possible distribution in the form of publications of nearly six hundred items—books, monographs and reviews, in English, French, Italian, German and Spanish, and perhaps other languages. His work in the history of Japanese mathematics was published in 1914. This was done in conjunction with Yoshio Mikami. His interest in the early history of mathematics in this country was again manifested when he had reprinted "The Sumario Compendioso of Brother Juan Diez, the Earliest Mathematical Work of the New World." This book was first issued in the City of Mexico in 1556. Again, Dr. Smith published with a facsimile of the first edition "The Geometry of René Descartes," translated from the French and Latin with the assistance of Marcia L. Latham. In addition to these, he published Greek mathematical tables and Hindu and Arabic numerals. These and many others too numerous to cite illustrate his universal tastes, interests and accomplishments. Again, nearer home, his interest in Colonial science, particularly in mathematics, was manifested in his constant search for the first beginnings of the teaching of mathematics in the Colonies. This was rewarded by his discovery of a Colonial algebra manuscript notebook written in 1739, found in a museum in York Village, Maine. He manifested keen delight in the works of others whose special interests were in Colonial science. This was one of the common bonds of interest between the writer and Dr. Smith. He himself wrote a number of biographical sketches of Colonial mathematicians for the "Dictionary of American Biography."

Dr. Smith's enthusiasm for the history of mathematics was due to the fact that to him it revealed what is most precious and most significant in our civilization. He believed the achievements of the past gen-

ration should be made the means of attaining still greater ends.

Brief as this appreciation is, we are all too conscious of the magnitude of the task. However, we can not close without a statement concerning the special delight which came to him in an honor which is rarely bestowed upon scholars. During an absence of four months in the winter of 1932 and spring of 1933, spent chiefly in Persia, Iraq and Syria, Dr. Smith traveled by motor upwards of 10,000 kilometers from the time he left Haifa until he reached Turkey. He secured more than 150 manuscripts—mostly Persian, Arabic and Hebrew. Among them were several mathematical pieces of importance, chiefly Arabic translations from the Greek classics, together with a fourteenth century manuscript of Omar Khayyám's algebra. The translations from the Greek include two Euclids, Archimedes on the circle and Aristarchus on astronomy. Also he supplemented his early nineteenth century manuscript of Ulug Begh's tables by three other earlier sets. In the lot were commentaries on al-Khowārizmī's algebra and Beha Eddin's arithmetic.

His collection, which contained also manuscripts of works on the Persian poets, he enlarged by copies, usually with miniatures, of the classics of Ferdousi, Hafiz, Sa'di, Omar Khayyám, Nazāmī, Omar ibn Ghares and others. His large library of Korans and Koranic literature, a few specimens of which are now in the Islamic exhibition in the Metropolitan Museum (New York), was greatly enriched by about 100 additional manuscripts, several with unusually fine decorations and bindings. These acquisitions formed part of his personal library of over 20,000 items which he presented to the library of Columbia University (the additional works to the special library of Teachers College).

It is well known that mathematical scholarship has a correlation with musical interpretations and appreciation, but seldom with poetical temperament and metrical construction.

In appreciation of Dr. Smith's new metrical version of Omar Khayyám's "Rubáiyát" in 289 quatrains, which was the first work to be worthily illustrated by a Persian artist of high standing, and in recognition of his interest in the mathematical achievements of the country, the Persian Government conferred upon him, in the presence of a distinguished audience, the gold star of the Order of Elim, decoration of the first rank. After an address by Professor Smith, who was introduced by H. Highness Feroughi, Minister of Foreign Affairs, the presentation was made by H. Highness Esfandiari, the oldest of the former ministers of state. The addresses upon the occasion were published in full in the Persian papers, in some cases with an English summary. An autographed portrait of H. I. Majesty, the Shah, was also among the highly prized souvenirs which were presented to him. He gave addresses in several of the cities and visited a number of the important excavations then in progress in Syria, Iraq and Persia.

In closing this brief sketch of his life and the material and spiritual aspects of it, may these always remain as a permanent tribute to his memory, to perpetuate his name and to enhance the already distinguished collection into which he has breathed the spiritual life of mathematics.

FREDERICK E. BRASCH,
Consultant in the History of Science
LIBRARY OF CONGRESS

SCIENTIFIC EVENTS

VITAL STATISTICS OF ENGLAND AND WALES

THE wartime upward trend in the birthrate in England and Wales was maintained during the first three months of this year. According to statistics given in *The Times*, London, the Registrar-General's Return of Births, Deaths and Marriages registered in the quarter ended March 31 records a total of 184,145 live births. This represented a rate of 17.9 per 1,000 of the population, the highest first quarter rate since 1926. There were 11,874 more births than in the first three months of 1943, when the rate was 16.9.

Boy babies numbered 94,964, giving a proportion of 1,065 boys to every 1,000 girls. The average for the 10 preceding first quarters was 1,060. Births registered exceeded deaths by 37,941.

The provisional infant mortality rate, 58 per 1,000 related live births, was 14 below the average for the 10 preceding first quarters, and was the lowest rate on record for this period of the winter.

The death-rate was 14.2, compared with 13.5 during the same period a year ago. From 1938 to 1942 the average rate was 16.2.

The number of marriages, 62,599, was the second lowest for any quarter since the war and exceeded by only 262 the number in the same period a year ago, when the lowest war-time quarterly total was recorded. The marriages were 12,972 fewer than the average number for the first quarters of the five years prior to 1943, but were 8,338 higher than the corresponding first quarter average for the five years immediately preceding the war.

THE FOURTH SCIENCE TALENT SEARCH

FORTY high-school seniors, with a natural aptitude for science, will have an opportunity to earn at least a part of their college education this year when the Science Clubs of America sponsors its fourth annual Science Talent Search. Open alike to boys and girls, the search will enlist the aid of more than forty thousand high-school teachers and principals, who will supply students with necessary information for entering the competition and who will administer the tests.

As a result of these tests the sum of $11,000 in Westinghouse Science Scholarships will be granted to at least ten and possibly to forty students, who will be named delegates to a five-day Science Talent Institute at Washington next March when the final competition for the scholarships will be held. All expenses will be paid. Scholarships may be applied toward a course in science or engineering at any college or university approved by a scholarship committee named by Science Service, which administers the search through the Science Clubs.

The Science Talent Search is conducted with the financial aid of the Westinghouse Electric and Manufacturing Company, which provides the scholarship awards as a contribution to the advancement of science in America. Any boy or girl who is a senior in a public, private or denominational secondary school may compete in the examinations.

The students who will be asked to attend the Science Talent Institute in Washington will be chosen on the basis of their showing in a series of qualifying requirements, including a statement written by the student on his own interests and ambitions; a written statement from his teacher on the student's aptitudes, ability and extra-curricular activities; a transcript of his scholastic records; and a thousand-word essay on the subject "My Scientific Project."

A three-hour science aptitude examination, designed to disclose the student's ability to understand and to reason, rather than to test his actual knowledge of science, will be given in the schools between December 1 and 27.

One boy and one girl will each receive Westinghouse Grand Science Scholarships of $2,400 ($600 per year for four years). Eight other contestants will receive 4-year scholarships of $400 each ($100 per year for four years). Additional scholarships amounting to $3,000 will be awarded at the discretion of the judges. These are Dr. Harlow Shapley, director of the Harvard College Observatory; Dr. Steuart Henderson Britt, of Washington, and Dr. Harold A. Edgerton, director, Occupational Opportunities Service of the Ohio State University. Those unable to use their scholarships before entering war service will find them waiting for them when they return to civilian life.

Complete details can be obtained by writing to Science Service, 1719 N Street, N.W., Washington 6, D. C.

AWARDS SPONSORED BY THE AMERICAN INSTITUTE OF NUTRITION

NOMINATIONS are solicited for the 1945 award of $1,000 established by Mead Johnson and Company to promote researches dealing with the B-complex vitamins. The recipient of this award will be chosen by a committee of judges of the American Institute of Nutrition, of which Dr. Arthur H. Smith, of Wayne University, is secretary, and the formal presentation will be made at the annual meeting of the institute at Cleveland on May 8, 1945.

The American Institute of Nutrition also will make the Borden Nutrition Award in recognition of distinctive research by investigators in the United States and Canada which has emphasized the nutritive significance of the components of milk or of dairy products. The award, which may be divided between two or more investigators, will be made primarily for the publication of specific papers, but the judges may recommend that it be given for important contributions over an extended period of time. Employees of the Borden Company are not eligible for this honor.

The formal presentation will be made at the annual meeting of the institute at Cleveland on May 8. To be considered for the award, nominations must be in the hands of the chairman of the nominating committee by January 15. The nominations should be accompanied by such data relative to the nominee and his research as will facilitate consideration for the award. Dr. Frederick J. Stare, Harvard Medical School, Boston, is chairman of the nominating committee.

AWARDS OF THE AMERICAN CHEMICAL SOCIETY

DR. JAMES BRYANT CONANT, president of Harvard University, chairman of the National Defense Research Committee, as already announced in SCIENCE, was presented with the Priestley Medal of the American Chemical Society at a general meeting of the society in New York City, "in recognition of service to science and to the nation."

The American Chemical Society prize of $1,000 was presented to Dr. Arthur C. Cope, associate professor of chemistry at Columbia University. Dr. Cope was cited for "outstanding research in organic chemistry."

Dr. Conant was Sheldon Emery professor of organic chemistry at Harvard University when he became president of the university in 1933. He had taught chemistry at Harvard since he completed his work for the doctor's degree in 1916. In 1932 he won

the William H. Nichols Medal of the New York Section of the American Chemical Society for "notable achievement in original research." He was the recipient of the Charles Frederick Chandler Medal of Columbia University in 1932, and of the Medal of the American Institute of Chemists in 1934. After receiving the Priestley Medal Dr. Conant delivered an address on "Science and the National Welfare."

Previous recipients of the Priestley Medal, named for the discoverer of oxygen and given every three years, have included the late Dr. Ira Remsen, president of the Johns Hopkins University; the late Dr. Edgar F. Smith, provost of the University of Pennsylvania; the late Dr. Francis P. Garvan, president of the Chemical Foundation of New York; Dr. Charles L. Parsons, of Washington, D. C., secretary of the American Chemical Society; the late Professor William A. Noyes, of the University of Illinois; Professor Marston T. Bogert, of Columbia University; and Dr. Thomas Midgley, Jr., of the Ethyl Gas Corporation, president of the American Chemical Society.

The investigations of Dr. Cope were said to be of timely value in the field of plastics and drugs. He is now engaged in war work, one of his principal tasks being the orientation and coordination of a program involving chemists and biologists. The citation reads in part:

> The interest of Dr. Cope in organic chemistry has been wide. The more than thirty papers which he has published are characterized not only by sound and mature experiments with difficult reactions, but also by a high order of independence of thought. Of the several valuable studies, the series on vinyl and allyl types is classical.
>
> The highly creative work involved in the synthesis of vinyl substituted active methylene compounds and the rearrangement of allyl groups in these types is of the greatest importance theoretically in throwing new light on the general field of condensation reactions and rearrangements. These studies are also of timely value in the broad fields of plastics and drugs.

The American Chemical Society Prize, provided by Alpha Chi Sigma, national scientific fraternity, was founded in 1931 by the late A. G. Langmuir. Previous recipients were Linus Pauling, Oscar Knefler Rice, F. H. Spedding, C. Frederick Koelsch, Raymond M. Fuoss, John Gamble Kirkwood, E. Bright Wilson, Jr., Paul Doughty Bartlett, Lawrence Olin Brockway, Karl A. Folkers, John Lawrence Oncley and Kenneth Sanborn Pitzer.

THE AMERICAN CHEMICAL SOCIETY AND THE UNIVERSAL OIL PRODUCTS COMPANY

OWNERSHIP of the Universal Oil Products Company of Chicago, one of the leading research and development companies of the country, will pass to the American Chemical Society under the terms of a gift announced at the annual dinner of the American Chemical Society by Dr. Thomas Midgley, Jr., president of the society.

The value of the Universal Oil Products Company is estimated at from $10,000,000 to $15,000,000. The income, which will be used for research under the direction of the society, is approximately $1,000,000 a year. The owners of the company have offered to give all their stock and securities to the society. The board of directors has accepted the offer in principle, and has appointed a special committee to complete the final details.

The Universal Oil Products Company is owned by six of the largest oil companies of the United States. These are the Phillips Petroleum Corporation, the Shell Oil Company, the Standard Oil Company of California, the Standard Oil Company of Indiana, the Standard Oil Company of New Jersey and the Texas Company. Dr. Midgley stated further that

> when the gift is completed the American Chemical Society will become a hundred per cent. owner of the company. The gift is made with the provision that the entire income therefrom shall be used by the society at its discretion for research in the fields of science relating to the oil industry.
>
> Results of the research will be published and made available to the public without payment. The donors will have no rights to such results greater than those of the public at large.
>
> The society will use the income to foster public welfare and education, aiding the development of our country's industries, and adding to the material prosperity and happiness of our people.
>
> The owners of the Universal Oil Products Company have advised the American Chemical Society that they have assured the company that no plan will be adopted involving its dissolution, nor will any action be taken that will affect its welfare. It will continue with its research and development efforts and continue to render the same service to the refining industry, especially its licensees, who number approximately one hundred. In other words, there is no intention to jeopardize the existence of the company nor the services it renders.
>
> The Universal Oil Products Company is presently devoting its entire efforts to a large part of the aviation gasoline program which comes under its jurisdiction and supervision. This program involves six basic processes of which there are approximately seventy-five installations in successful operation in the different refineries scattered throughout the nation.

SCIENTIFIC NOTES AND NEWS

THE American Gastroenterological Association dedicated its official journal, *Gastroenterology*, for July to Dr. Anton J. Carlson, professor of physiology emeritus of the University of Chicago. Dr. Carlson was presented on June 12 with the Friedenwald Medal of the association for 1944.

DR. EDWARD ROBINSON BALDWIN, who recently retired as director of the Trudeau Foundation, Saranac Lake, N. Y., celebrated his eightieth birthday on September 8. He continues active as chairman of the Executive Committee of the Trudeau Sanatorium.

DR. MAXIMILIAN TOCH, paint technologist, president of Toch Brothers, Inc., and vice-president of Standard Varnish Works, Inc., has been elected an honorary member of the American Institute of Chemists, of which he is a charter member and a former president.

DR. NORMAN A. SHEPARD, chemical director of the American Cyanamid Company at Stamford, Conn., has been elected chairman of the American Section of the Society of Chemical Industry.

THE Royal College of Physicians has appointed Dr. John Parkinson, consulting geologist, Harveian Orator for 1945, and Dr. W. Russell Brain, of London, neurologist, Bradshaw Lecturer for 1945. Sir Edmund Spriggs, of Wales, physician, will deliver on October 18 the Harveian Oration for 1944.

DR. SIDNEY J. FRENCH, professor of chemistry at Colgate University, has been appointed acting dean of the faculty.

WILLIAM GOODMAN, consulting engineer for the Trane Company at LaCrosse, Wis., has been appointed research professor of refrigeration and air conditioning at the Illinois Institute of Technology.

A. A. HALL, of the Royal Aircraft Establishment, has been appointed Zaharoff professor of aviation and head of the department of aeronautics at the Imperial College of Science and Technology, London, to succeed Professor Leonard Bairstow.

PROFESSOR FRANK GOLDBY, professor of anatomy and histology at the University of Adelaide, has accepted appointment to the chair of anatomy at the University of London, tenable at the St. Mary's Hospital Medical School.

DR. DENIS M. ROBINSON, of the Tele-communication Research Establishment of the British Air Ministry, has been appointed professor of electrical engineering at the University of Birmingham.

EDWARD MACKAY, since 1914 in charge of the Laboratory of Fruit and Vegetable Chemistry of the U. S. Department of Agriculture at Los Angeles, has retired after forty-two years in government service.

IT is reported in *Chemical and Engineering News* that E. F. Kelly, for nearly twenty years executive secretary of the American Pharmaceutical Association, Washington, D. C., plans to retire. He has asked that a successor be appointed not later than the 1945 meeting of the association. A committee is being appointed to select candidates to be presented to the council.

DR. GUSTAV EGLOFF, director of research of the Universal Oil Products Company, has been elected a director of the Chicago Technical Societies Council, which represents forty scientific and technical organizations in the Chicago area, with a membership of fifteen thousand. He has also been elected a trustee of the Western Society of Engineers, which is one of the organizations represented in the Chicago Technical Societies Council.

DR. LAWRENCE W. BASS, director of the New England Industrial Research Foundation, Boston, formerly assistant director of the Mellon Institute, has become associate director of chemical research jointly for the U. S. Industrial Chemicals, Inc., and the Air Reduction Company, Inc. He is responsible for the development of plans for the coordination and expansion of research of the two companies.

DR. MELVILLE SAHYUN has been appointed divisional vice-president of the Frederick Stearns and Company Division of Sterling Drug, Inc. Dr. Sahyun has been associated with the firm since 1934, first as director of biochemical research and since 1943 as director of research.

DR. FREDERICK F. YONKMAN, professor of pharmacology and therapeutics and chairman of the department at the College of Medicine, Detroit, of Wayne University, has become chief pharmacologist in the research division of Ciba Pharmaceuticals, Inc., of Summit, N. J.

DR. NORMAN P. ALLEN, a member of the staff of the research laboratories of Mond Nickel Company, Ltd., has been appointed superintendent of the department of metallurgy of the British National Physical Laboratory in succession to Dr. C. Sykes.

DR. THOMAS RENTON ELLIOTT has retired from the honorary secretaryship of the Advisory Board to the Beit Memorial trustees after serving for fourteen years. Dr. A. N. Drury, director of the Lister Institute, London, has been appointed his successor.

DR. H. J. T. ELLINGHAM, of the Imperial College of Science and Technology, South Kensington, has

been appointed secretary of the Royal Institute of Chemistry.

DR. RALPH L. MILLER, of the department of geology of Columbia University, is completing a survey of the manganese deposits of Aroostook County, Me., for the U. S. Geological Survey. He will return shortly to Lee County, Virginia, where an investigation of the petroleum resources of southwest Virginia is going forward under his direction.

DR. H. H. BENNETT, of the U. S. Soil Conservation Service, has arrived in Johannesburg, South Africa, where he will make a two-months study of the soil-erosion problem.

DR. J. ALLEN SCOTT, associate professor of epidemiology and medical statistics at the School of Medicine of the University of Texas, who is participating in the organization and work of a parasitological survey in the Amazon area at Belem, Brazil, under the auspices of the Rockefeller Foundation and the Office of Coordinator of Inter-American Affairs, will return to the School of Medicine in November.

DR. SALVADOR MASSIP, who has been visiting professor of geology and geography at Smith College during 1943–44, has returned to the University of Havana.

DR. ANTON J. CARLSON, professor emeritus of physiology of the University of Chicago, will be on October 2 the first guest lecturer of the newly established lectureship of the Alpha Omega Alpha fraternity of Tulane University.

THE Instrument Society of Washington will hold its first autumn meeting in the Auditorium of the Department of the Interior, Washington, D. C., on September 26 at 8:00 P.M. At that meeting J. C. Peters, of the Leeds and Northrup Company, will deliver an address on "Automatic Control—Fundamentals and Instruments." Admission is open to the public.

DR. MARK R. EVERETT, professor of biochemistry at the School of Medicine of the University of Oklahoma, lectured recently at the Medical Branch at Galveston of the University of Texas. He spoke on "Metabolic Factors in Clinical Medicine."

AT the dinner meeting on Friday, November 15, of the Chicago Section of the American Chemical Society, the main speaker will be Dr. C. F. Kettering, of the General Motors Corporation. The meeting is being held in connection with the third biennial National Chemical Exposition and National Industrial Conference.

THE annual convention of the American Association of Textile Chemists and Colorists will be held in Atlantic City from October 12 to 14.

A POSTGRADUATE Assembly on Nervous and Mental Diseases and War will be held by the Institute of Medicine of Chicago on November 1 and 2 in the Palmer House. It will be devoted to phases of neurology, psychiatry and neurosurgery that are of particular importance at this time to clinicians, to specialists and to lay workers. The program will include five addresses on each of the two mornings and on one afternoon. There will be a "Neuropsychiatric Information Please" program on the first evening and panel discussions on the afternoon of the second day. The seventeenth Pasteur Lecture will be given on that evening by Dr. Edward A. Strecker, president of the American Psychiatric Association.

AT a recent meeting at the Medical Branch at Galveston of the University of Texas, a Southwest Section of the Society for Experimental Biology and Medicine was organized. Meetings are planned to be held three times a year in rotation at Southwestern Medical College, Dallas; at the Medical College at Houston of Baylor University; at the University of Texas, Austin, and occasionally at the University of Oklahoma Medical School, Oklahoma City.

THE British Institution of Electrical Engineers has offered to endow for a limited period (probably five years) a professorship of electrical engineering at the University of Cambridge. Although perpetual endowment is customary, it is reported that the university authorities appear to be willing to make the necessary provision for the continuance of the professorship if external aid is not forthcoming.

A LEO HENDRIK BAEKELAND AWARD has been established by the New Jersey Section of the American Chemical Society. It will consist of $1,000 and a gold medal suitably inscribed, and may be presented biennially to an American chemist who has not yet reached his fortieth year in recognition of accomplishments in pure or industrial chemistry. Nominations will be received by the chairman of the section in October of the calendar year preceding the date on which the award will be made and not later than December 1. The recipient will be announced each year at the regular February meeting of the society and the presentation will be made in May. The award was established with the cooperation of the Bakelite Corporation, New York City. Dr. Baekeland, who died on February 23 at the age of eighty years, was best known for the invention of the first commercial synthetic resin.

AN Inter-American Institute of Agricultural Sciences has been established to encourage and advance the development of the agricultural sciences in the American republics through research, teaching and extension activities. The establishment of the institute has been approved by the U. S. Senate.

AN Associated Press dispatch from Stockholm reports that six Nobel prizes will be awarded for 1944. There will be two prizes in physics, two in chemistry, one in letters and one in medicine.

IT is reported that the Society for Visiting Scientists, with premises at 5, Old Burlington Street, W.1, London, has been founded on the initiative of the British Council, in consultation with the Royal Society, to provide a meeting place and information center where scientists can be given advice and information about scientific institutions in Great Britain. In many other countries houses and organizations have been established for the use of visiting scientists and scholars. One of the best known of these is the Fondation Universitaire, Brussels, and there is another center in Leningrad, which occupies one of the palaces next to the Winter Palace beside the River Neva. London hitherto has had no center of the same kind, even on a modest scale, for it is not part of the ordinary work of scientific societies to look after the more general needs of visiting scientists. The information center now will be at their disposal, and any scientist arriving in Britain can go at once to the house, use the facilities offered and find out how he may apply for membership. The president of the society is Professor F. G. Donnan, who is also the acting chairman, and the chairman of the honorary council is General Smuts. The honorary presidents of the society are Sir Malcolm Robertson, M.P., and Sir Henry Dale.

DISCUSSION

THE OBLIGATIONS OF A SCIENTIST

THE criticism has frequently been raised that scientists are as much responsible for the evils of civilization and the horrors of war as they are for the good arising from their contribution to our present technical advancement. The implication of the criticism is that scientists should either limit the breadth of their activities or else guide the application of their work so that their results could not possibly be misused. The object of this note is to make two points: one, there is no valid basis for such criticisms of science; two, a scientist has certain obligations which, if met, discharge his responsibilites to society.

The fallacy of a scientist being able to predetermine all the ultimate uses to which the results of his efforts might be put is self-evident. In addition, it could be argued extensively and successfully that the good arising from the results of scientific effort has far exceeded the evil. But in a larger sense science is responsible for neither. The principal concern of science is to add to our knowledge. It should not be considered primarily responsible for the use society makes of that knowledge. In the final analysis it is the option of society to approve or reject the utilization of these additions. Many cases are on record in which society has permitted the withholding of technical advancements, even though they were of obvious benefit. Is it not then equally the option and obligation of society to reject such applications of knowledge as would appear to be detrimental to the common good?

The duty of the scientist is to search for truth disinterestedly and to present his findings without prejudice. One of the principal duties of students of social problems should be to examine and recommend the best utilization of the advancements of science.

Such a division of responsibility is inherent with the complexities of our civilization. The achievement of an advance of real worth may require the undivided attention of one or more scientists for an extended period. Fortunately, the results of years of work can often be summarized concisely, even into a single word such as "penicillin." Although many scientists can suggest applications for their findings, it requires also the full cooperation of those concerned with social problems to achieve the maximum benefit from even such an obviously desirable discovery as penicillin. The final responsibility of the utilization of knowledge rests upon this group and not upon the scientists who discover it.

Does this mean then that the scientist is free to become a recluse and ignore the world about him in the pursuit of his scientific interests? No, a scientist has obligations to his calling and to society which can not be ignored.

First, and most important, is his obligation to the scientific method. Too often does one meet workers in scientific fields whose fine training has been lost through subjugation of scientific principles to personal whimsey. A scientist must constantly reexamine himself and his work and keep both in line with the most rigorous scientific precepts. Only by so doing can he be sure that his efforts will be a real and lasting contribution to society.

Second, a scientist must conscientiously instruct those who come under his tutelage, whether they be students or associates. He must instruct them both in the scientific method and in knowledge which has been established. It is as essential to pass on the scientific method to future generations as it is to practise it. Courses which are alleged to emphasize training in the scientific method should not ignore it

completely! (In this connection Richmond's[1] recommendation of a course in "scientific method" for all college students is one that should be considered most seriously). It is important also for a scientist to fulfil his teaching obligations completely. A teacher in science must constantly add to his personal store of knowledge new facts as they are made known. He must sift these carefully and give his students a sound foundation to which they can add the advancements that accrue in their lifetimes.

Third, a scientist has the obligation to indicate clearly to society what good he believes might be achieved from his contribution to knowledge. This is an obligation which should be taken seriously. Although he may not know fully the needs of society, he knows his work, and he should where possible take the first step towards the full utilization of his results.

It is possible that many would wish to modify these suggestions. It might be valuable to amplify and extend them. If, however, this discussion stimulates the reader to consider his relations to society and the obligations which they impose, the writing of this note will have been well justified. If, however, a scientist should acknowledge the three obligations listed here and conscientiously attempt to fulfil them, he is worthy of a respected place in society and his contributions will be lasting. After the scientist does his part, it is then the duty of those who guide society to see that means are available for the utilization of the achievements of science for the highest good.

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BIOLOGICAL TERMINOLOGY

AN additional point may be considered in the discussion of the college course in elementary biology.[1]

We may expect that the course will justify the effort required in installing and giving it, and that it will overcome the distrust of specialists and win a better place in the curriculum than that of a tolerated alternative. These hopes can scarcely be fulfilled, however, while many fundamental terms, common to all branches of biology, are used in distinctly different senses by specialists in the different branches. If the instructor in biology, being a zoologist, teaches these terms definitely in the senses to which he is accustomed, he imposes a handicap upon any of his students who may subsequently take up botany. This is the factual basis of the trite witticism that biology is botany taught by a zoologist.

[1] SCIENCE, 99: 2576, 385, 1944.

[1] The presentation of this course is defended in SCIENCE, volume 99 (1944), by G. Alexander, p. 78; L. J. Milne, p. 471; L. H. Taylor, p. 364; and M. B. Visscher, p. 383.

With diffidence, I submit the results of efforts to frame generally acceptable definitions for some of these terms. The results would be more recognizably authoritative if it could be shown that each term had been traced back through historical usage to original publication. Such is not the case. The definitions presented are based on much reading of text-books, on conversation and on experience in both ends of the classroom. In intention, at least, due weight has been given to original and current usage, to etymology and to the application of words to facts.

CELL AND PROTOPLAST

The word "cell" was brought into biological usage by Hooke, who designated by it minute cavities discovered by him in cork. Lamarck and Mirbel are said first to have formulated the principle that organisms consist entirely of cells and cell products. According to this principle, the cell may be defined as the unit of structure and function in organisms. In animal bodies, most of the units so described consist entirely of living substance. If, however, one defines the cell as the unit body of protoplasm, one comes into conflict with the basic meaning of the word, and with prior botanical usage which applies it to walled spaces from which the living substance has disappeared. The living unit is properly designated by a term ascribed to Hanstein:

A protoplast is a unit body of protoplasm.

The infallible mark of the individual protoplast is not the nucleus. It is the continuous differentiated living membrane called the plasma membrane or cell membrane.

A cell is a unit of structure and function in organisms, consisting of one protoplast together with any lifeless structures which may be attached to it, or of the lifeless remains of the same.

Thus the unit of the bodies of animals is at the same time a protoplast and a cell; the active unit in plants, containing a vacuole and possessing a cell wall outside the cell membrane, is a cell of which a protoplast is a part; a fiber of cotton is a cell from which the protoplast has disappeared.

RESPIRATION AND ENERGESIS

Forty years ago, the botanist Barnes, studying respiration according to the accepted botanical meaning of the term (which excludes breathing or gas exchange) consulted zoological literature and found out that breathing or gas exchange is precisely what it means. The zoological usage is justified by priority and etymology; Barnes coined the term "energesis" to replace it as it had been used in botany. That this term has not been in general use is an example of the perversity natural to man.

Energesis includes all metabolic processes by which energy is released. It occurs at all times in all living parts of all organisms.

Respiration includes all processes by which a gas necessary for energesis is taken into an organism, or by which a gas produced by energesis is expelled.

The relationship between respiration and energesis is that which exists between a draft and a fire. Respiration is generally but not universally associated with life. Photosynthesis, where it is proceeding at a perceptible rate, furnishes the one gas and removes the other by chemical processes taking place upon the spot; it makes respiration unnecessary.

MITOSIS AND CELL DIVISION

In most organisms, whenever the division of a nucleus approaches completion, the cell containing it begins to divide. Many biologists think of the division of the nucleus and that of the cell as inseparable, and apply the term mitosis to the entire process. There exist, however, a considerable number of examples of the separation of nuclear division and cell division. In cells of *Vaucheria* and *Rhizopus*, and in the endosperms of most seed plants, mitosis takes place repeatedly before any cell division occurs. Bacteria exhibit cell division in the absence of any process recognizable as mitosis. The term *karyokinesis*, construed as an exact synonym of mitosis, refers, etymologically, specifically to the nucleus. The following definition is perhaps tenable:

Mitosis or karyokinesis is nuclear division in the typical fashion, producing two nuclei of exactly the same genetic constitution (overlooking aberrations) as the original one.

The use of many other terms is open to discussion, but I forbear.

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THE POSSIBLE ROLE OF CHARA FRAGILIS IN MOSQUITO CONTROL

IN 1919 Caballero[1] in Spain published papers on the role of *Chara foetida* as a mosquito larvicide. In 1924 Barber[2] in the United States secured negative results with *Chara robinsii*. There has been considerable study of the subject, which was summed up in 1930 by Matheson,[3] who suggests that ingestion of oxygen bubbles given off by the plant may be injurious to mosquito larvae.

The writer has experimented with *Chara fragilis*, furnished by the botanical institute of Central University of Quito, and has used the five most common mosquito species of Ecuador. These are *Culex fatigans, Aedes aegypti, Aedes eupochamus, Anopheles albimanus* and *Anopheles pseudopunctipennis* var. *pseudopunctipennis*. Two of these species are malaria vectors, while one may carry yellow fever and dengue. Experiments with each of the five species were conducted in the same way, as follows:

(1) In an aquarium with growing *Chara fragilis* were placed 4 eggs; in another aquarium with hay infusion were placed 4 eggs. Normal hatching and development occurred in both.

(2) Four eggs were placed in a Chara infusion and compared with 4 in water. Normal development occurred in both.

(3) In the same way a water extract of fresh stems of Chara was compared with water, using 4 eggs in each for each species. Again development was normal in both media.

(4) Oospores of *Chara fragilis* were dried, crushed, mixed with yeast, and given to growing larvae of the first, second, third and fourth instars. These larvae developed normally, as did those in the check.

(5) Rotted stems of *Chara fragilis* were used in the same manner as the spore preparation, with the same results.

It may be noted that this Chara was found with other algae in pools where mosquitoes were breeding in nature. It was also noted that larvae ingested small particles of Chara, as Barber observed.

These experiments fail to indicate any pronounced controlling action of *Chara fragilis* against mosquitoes.

ROBERTO LEVÍ CASTILLO

ENTOMOLOGICAL SERVICE,
ARMY OF ECUADOR

SCIENTIFIC BOOKS

CLINICAL DIAGNOSIS

Clinical Diagnosis by Laboratory Examinations. By JOHN A. KOLMER. First edition, revised. xlii + 1247 pp. 78 figs. 137 tables. New York: D. Appleton-Century Company, Inc. 1944. $10.00.

THE material in this book is concerned primarily with two phases of the physician's contact with his patient; when he is trying to decide what laboratory examinations will aid in either diagnosis or prognosis and when he has received the laboratory report and

[1] A. Caballero, *Bol. R. Soc. Esp. Hist. Nat.*, 19: 449–455, 1919.

[2] M. A. Barber, *Pub. Health Repts.*, Washington, 39(13): 611–615, 1924.

[3] R. Matheson, *Am. Nat.*, 64: 56–86, 1930.

is seeking to interpret it in relation to other findings.

The subject-matter is presented in three parts. Part I (641 pp.) is entitled "The Clinical Interpretation of Laboratory Examinations" and includes a comprehensive discussion of the many laboratory examinations from the fields of hematology, biochemistry, physiology, toxicology, parasitology, bacteriology, immunology and mycology, which are a part of the armamentarium of modern medicine. Each subject is accompanied by a discussion of normal functions and values, to aid in the understanding of pathological variations. Naturally, much of this material is standard, but the author has drawn considerably on his own extensive experience for aid in interpretation, and there is much recent material on such subjects as hormones and vitamins, for example, which in general is of excellent quality and not readily available elsewhere.

In Part II (328 pp.), the many diseases for which laboratory data are of value are discussed briefly but individually, from the point of view of clinical characterization and relevant laboratory information. There is considerable repetition of material from Part I in this section, which is perhaps unavoidable.

Part III (142 pp.) presents the technique of certain of the more common laboratory examinations and is intended for use in the teaching of clinical pathology and in the smaller laboratories. This section was not meant to be extensive, nor is it; its scope can be illustrated by the chapter on quantitative blood analysis, which contains, in addition to the recent copper sulfate method of Phillips, Van Slyke, *et al.*, for determining specific gravity of whole blood and plasma, methods for the following: sugar, CO_2-combining power, urea nitrogen, non-protein nitrogen, the plasma proteins, bilirubin and the sulfonamides. Visual colorimetry is described; modern photometric procedures, which are now routine in many hospital laboratories, have been ignored.

A noteworthy feature of the book is the author's emphasis upon what may be called the "pre-laboratory" phase of a laboratory examination, *i.e.*, the proper preparation of the patient and collection of material. The author feels, and rightly, that too much laboratory information may be rendered valueless because of ignorance or neglect in this respect. Another feature is the many tables found throughout the book which summarize textual material; while these may be open to the criticism that they tend to make controversial material appear established, there is no question but that they are a great convenience when used intelligently. There is also an excellent and up-to-date bibliography for each chapter.

Those portions of the book which deal with fundamental biochemical material are in general quite unsatisfactory. The sections on acid-base balance (pp. 99–102, 850–853) will scarcely be of value to any one who does not already understand the subject; a portion of the treatment of alkalosis on page 100 appears to be missing entirely. In the discussion of nitrogen metabolism such statements as these are found: that creatinine is a product of endogenous protein metabolism (pp. 73, 107); that urea is one of the chief products of protein digestion as well as of protein metabolism in the tissues (p. 102); that it is a major source of urinary ammonia (p. 72), and that it is formed from ammonium carbamate (p. 107); and in the table on page 62 we are told that the creatinine content of the urine is independent of the diet, whereas on page 73 the true state of affairs is given. On page 103 we read that the fatty acid equivalent of ingested protein is 42 per cent. by weight, a value presumably obtained by subtracting 58 from 100.

These are small points, perhaps, in only one of the many fields covered by the author, but they represent the level of biochemical knowledge found throughout the book, and this level must be regarded as inadequate. It does not appear unreasonable to expect as high a degree of technical precision in any particular field embraced by the author's treatment as one should find in a specialized treatment of that field, even though the scope be necessarily limited.

The book is printed in type which is clear and easy to read, and the general typographical arrangement is excellent; typographical errors are not too numerous. Those who purchased the first edition of this book, which appeared in September, 1943, priced at $8.00, will be interested in knowing that no differences whatsoever have been noted between the two editions except in (a) price, (b) the inclusion in the revised edition of the specific gravity method mentioned above.

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CHEMISTRY

Systematic Inorganic Chemistry. By DON M. YOST and HORACE RUSSELL, JR. New York: Prentice-Hall, Inc., publishers. 423 pp. $4.60.

PROFESSOR YOST and Dr. Russell have set out to write a book which is complete on the elements discussed—nitrogen, phosphorus and the oxygen group—and have succeeded notably. "Systematic Inorganic Chemistry" will undoubtedly remain the standard reference text in its field for many years. By critical

selection of experimental data, together with the careful inclusion of experimental data in support of each conclusion presented, the authors have achieved the happy result of a book that is authoritative without being encyclopedic.

Among the best features of the treatment are the following:

(1) For each molecule whose structure is definitely known from electron-diffraction or x-ray data, the interatomic distances and bond angles have been given and a helpful scale drawing of the molecule included. For molecules whose structure must be deduced from other evidence (*e.g.*, spectra, freezing-point depression, chemical reactivity) the actual data are cited.

(2) By judicious use of tables, the authors have been able to include a wealth of physicochemical data for each compound, without interfering with the continuity of the text.

(3) About half the book is devoted to the methods of preparation and the principal reactions of the compounds discussed. In these sections the authors' physicochemical approach shows to great advantage. Each equilibrium is discussed from a quantitative, thermodynamic point of view. Numerical reaction-rate laws, or occasionally tabulated rate data, are given for almost every reaction discussed. For complex reactions (those of nitrous acid, hypophosphorus acid, or peroxydisulfate, to mention a few) the probable reaction mechanisms have been outlined.

"Systematic Inorganic Chemistry" should prove to be not only a valuable text for the graduate students for whom it was designed, and not only a reference book for any research worker who uses these inorganic compounds, but also a challenge to other inorganic chemists to write equally good books covering other parts of the periodic table.

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SPECIAL ARTICLES

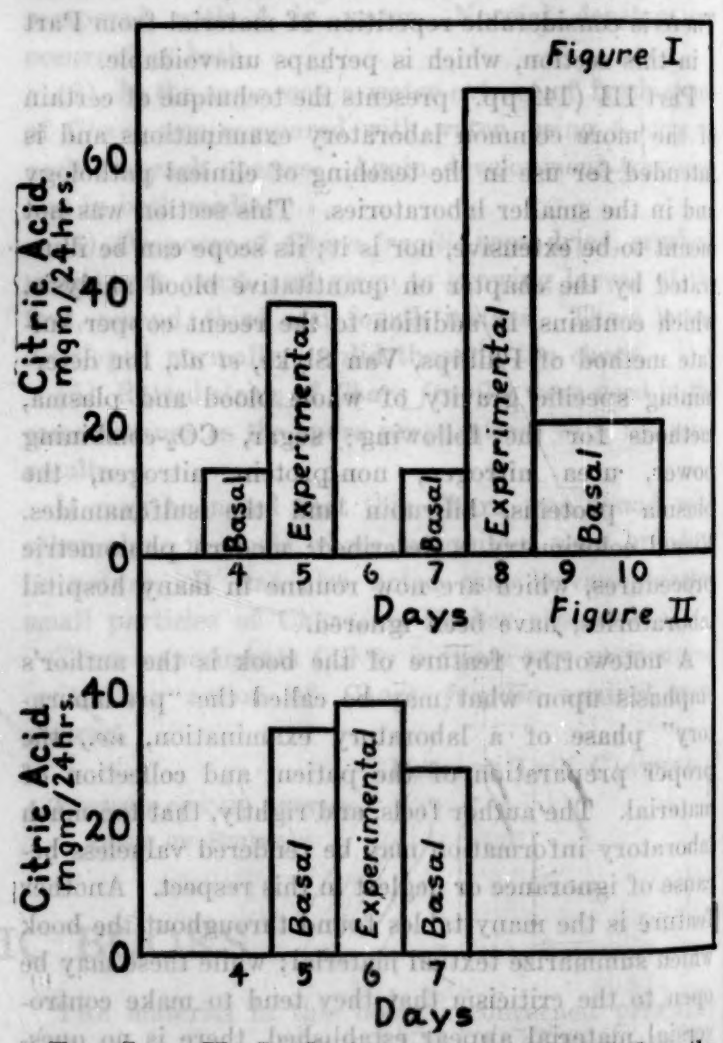
THE EFFECT OF COCARBOXYLASE ON THE CONVERSION OF FAT TO CARBOHYDRATE

IN a recent study on the conversion of fat to carbohydrate, two lines of attack suggested definite possibilities. The first arose from a realization of the fact that odd-numbered fatty acids are readily converted to glucose[1]; the second, from the apparent necessity of a catalytic reaction to increase the sugar production over that already present in an animal. Since the experimental diabetic animal produces sugar in large quantities, it was conceivable that the second approach might increase sugar output in this animal.

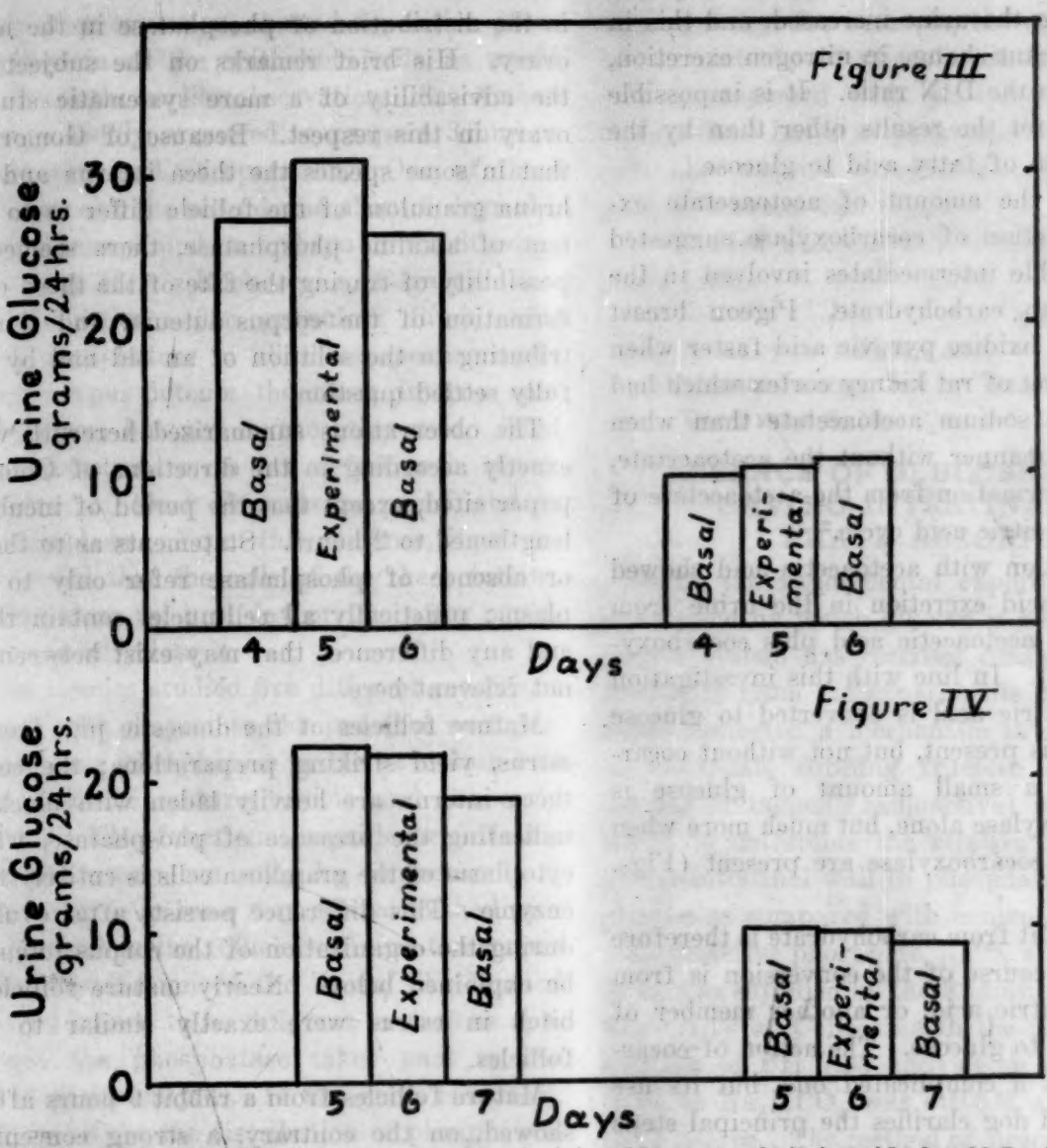
If one could cause an even-numbered carbon fatty acid chain to be converted to an odd-numbered carbon chain, the conversion should proceed from that point to glucose. The reverse reaction, in which an odd-numbered carbon acid (pyruvic) is converted to an even carbon chain, is known. The catalyst involved is cocarboxylase. Its action is believed to involve reversibly the liberation or combination of CO_2 from pyruvic and back to pyruvic.

The molecule that most closely resembles pyruvic acid and that is intermediate in the breakdown of fat is acetoacetic acid. It differs from pyruvic acid only in having one more carbon and in having the keto group in the beta position instead of the alpha. Since the alpha keto acid can form sugar, it was reasoned that the beta keto acid should, after decarboxylation, perform in a similar manner, though probably to a much less extent. It therefore seemed worth while to

[1] J. S. Butts, H. Blunden, W. Goodwin and H. J. Deuel, Jr., *Jour. Biol. Chem.*, 117–131, 1937.



FIGS. I AND II. In the first experimental period on the fifth day off insulin, 6.54 grams of the acetoacetate radical were given by stomach tube along with 32.9 milligrams of cocarboxylase. On the eighth day off insulin, 6.54 grams of the acetoacetate radical plus 33.5 milligrams of cocarboxylase again were administered by stomach tube. In the last experimental period the animal utilized 3.77 grams of the acetoacetate radical, excreting as citric acid



FIGS. III AND IV. Fig. III shows the results of giving 12 grams of citric acid plus 29.7 milligrams of cocarboxylase to a depancreatized dog by stomach tube during the experimental period. A 98 per cent. theoretical conversion to glucose was obtained. Fig. IV shows results from the same dog, given the same dose of cocarboxylase as in Fig. III, but without citric acid.

try the effect of cocarboxylase in the diabetic animal. It was, of course, realized that pyruvic acid breakdown is catalyzed by this enzyme and that carbohydrate combustion consequently might be increased, but in the totally diabetic animal this reaction would be minimal.

In most of these studies the depancreatized dog was used as the experimental animal. The fourth to sixth day off insulin, after complete healing, proved to be the best starting point.

Cocarboxylase injected intravenously was soon found to have the effect of increasing sugar excretion. Illustrative results are shown in Table 1.

Under favorable conditions the respiratory quotient (R.Q.) was lowered from the neighborhood of 0.70 to 0.59. It was lowered further, often to 0.51 (Exp. I), by the feeding of sodium butyrate to the animal treated with cocarboxylase. This change in R.Q. was brought about principally by a falling off in the CO_2 expired. Theoretical calculation showed that the assimilation of CO_2 must have taken place to account for the decreased R.Q.

Simultaneously with the lowering of the R.Q., the

TABLE 1

Dog No.	I	VIII	IX	XI	XII
Basal R.Q. *	0.68	...	0.71	0.69	0.67
R.Q. after injection of cocarboxylase	0.51	...	0.65	0.60	0.59
Basal urinary glucose,† gm/hr	0.65	1.79	1.00	1.19	1.14
Experimental urinary glucose,† gm/hr	1.17	2.53	1.30	1.69	1.56
Basal D:N ratio	2.59	5.1	2.75	3.1	3.3
Experimental D:N ratio	3.33	7.1	3.67	4.0	5.7
Amount of cocarboxylase injected mg.	10	5	8	5,5,5.5	15 & 18
Sodium butyrate injected gm.	4	0	0	0	0

* The R.Q.'s were measured over a 10-minute period by the Tissot-Haldane method. The lowest values are given, as obtained in periods starting from 10 to 30 minutes after the last injection.

† Urinary glucose and nitrogen values were measured over a 1- to 4-hour period. The experimental period included the R.Q. determination.

only about 1.7 per cent. of the amount utilized. Data from a different dog are represented in Fig. II. Thirty milligrams of cocarboxylase alone were administered by stomach tube in the experimental period.

excretion of sugar in the urine increased, and this in turn, without significant change in nitrogen excretion, caused an increase in the D:N ratio. It is impossible at present to interpret the results other than by the process of conversion of fatty acid to glucose.

An alteration in the amount of acetoacetate excreted after introduction of cocarboxylase suggested studies on the possible intermediates involved in the conversion of fat to carbohydrate. Pigeon breast muscle was found to oxidize pyruvic acid faster when treated with an extract of rat kidney cortex which had been incubated with sodium acetoacetate than when treated in the same manner without the acetoacetate, thus indicating the formation from the acetoacetate of some member of the citric acid cycle.[2]

Further investigation with acetoacetic acid showed an increased citric acid excretion in the urine from diabetic animals fed acetoacetic acid plus cocarboxylase (Figs. I and II). In line with this investigation it was found that citric acid is converted to glucose when cocarboxylase is present, but not without cocarboxylase. Actually a small amount of glucose is formed with cocarboxylase alone, but much more when both citric acid and cocarboxylase are present (Figs. III and IV).

The formation of fat from carbohydrate is therefore demonstrated. The course of the conversion is from acetoacetic acid to citric acid, or another member of the cycle, and thence to glucose. The action of cocarboxylase probably is a complicated one, but its use in the depancreatized dog clarifies the principal steps by which the conversion proceeds. Doubtless the same reactions occur in the normal subject fed high fat diets, but because insulin is present the glucose formed is for the most part immediately oxidized and therefore no change in the R.Q., or at most very small changes, are detectable.[3]

The author is indebted to Professor J. R. Murlin for his advice and criticism throughout this investigation.

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ALKALINE PHOSPHATASE IN THE OVARIAN FOLLICLES AND CORPORA LUTEA

IN a report on the distribution of alkaline phosphatase in normal tissues, made possible by an ingenious method of demonstrating that enzyme in sections, Gomori[1] called attention to the great variation in the distribution of phosphatase in the mammalian ovary. His brief remarks on the subject suggested the advisability of a more systematic study of the ovary in this respect. Because of Gomori's finding that in some species the theca interna and the membrana granulosa of the follicle differ as to their content of alkaline phosphatase, there seemed to be a possibility of tracing the fate of the theca cells in the formation of the corpus luteum, and thus of contributing to the solution of an old and by no means fully settled question.

The observations summarized herewith were made exactly according to the directions of Gomori in the paper cited, except that the period of incubation was lengthened to 2 hours. Statements as to the presence or absence of phosphatase refer only to the cytoplasm; practically all cell-nuclei contain the enzyme and any differences that may exist between them are not relevant here.

Mature follicles of the domestic pig, from sows in estrus, yield striking preparations; the cells of the theca interna are heavily laden with black granules indicating the presence of phosphatase, whereas the cytoplasm of the granulosa cells is entirely free of the enzyme. This difference persists after ovulation and during the organization of the corpus luteum, as will be explained below. Nearly mature follicles from a bitch in estrus were exactly similar to the sow's follicles.

Mature follicles from a rabbit 9 hours after mating showed, on the contrary, a strong concentration of phosphatase in the granulosa but none in the theca interna. In continuance of this condition, in corpora lutea about 8 hours, 3 days and 5 days old, respectively, the lutein cells (most or all of them derived from the granulosa) were laden with the enzyme. Gomori found no phosphatase in rabbits' corpora lutea, except in endothelial cells, but he did not state the age of the corpora lutea and possibly he studied only retrogressive corpora. Ripening follicles ca. 0.8 mm in diameter, of a guinea pig in estrus, less than 1½ hours after opening of the vaginal closure membrane, showed a heavy black deposit representing phosphatase in the theca interna, and a light deposit in the granulosa. Gomori reported the theca interna of the rabbit negative, but he probably studied only immature follicles. Three days and nine days after ovulation, and in a number of pregnant animals given me by Dr. W. L. Hard, the lutein cells were strongly positive, confirming Gomori's statement.

A recently ruptured follicle of the rhesus monkey, obtained within 24 hours after ovulation, while theca interna and granulosa were still clearly distinguishable, showed a strong concentration of phosphatase in both layers. A corpus luteum from another monkey,

[2] The author is indebted to Mr. John J. Kelly and Mr. Robert E. Gosselin, of the Department of Physiology, for their assistance in this part of the work.

[3] E. E. Hawley, C. W. Johnson and J. R. Murlin, *Jour. Nutrition*, 6:523, 1933.

[1] G. Gomori, *Jour. Cell. and Comp. Physiol.*, 17: 71–81, 1941.

about 9 days after ovulation, showed a positive phosphatase reaction in all the epithelioid cells, as would be expected from the earlier observation. Dr. Arthur T. Hertig very kindly arranged to prepare 3 human corpora lutea obtained at operation. One of these was about 1 day old, the second was about 5 days old, and the third accompanied an embryo of the 8th day, No. 8225 of the Hertig-Rock series, Carnegie Embryological Collection. The granulosa lutein cells were free of phosphatase in all three specimens; in the youngest corpus luteum the theca interna contained the enzyme, but not in the other two. That the latter preparations were not defective is shown by the presence of black deposits in nuclei and in endothelial cytoplasm. From this evidence, it is tentatively concluded that the cells of the theca interna contain phosphatase up to a day or two after ovulation but subsequently lose it.

Thus in six species studied five different conditions were observed with respect to the presence and persistence of alkaline phosphatase in the granulosa and theca interna of the mature follicle and the early corpus luteum. The functional significance of this hormone in the ovary can only be conjectured; it seems likely that it is in some way related to the lipids which are plentiful in the follicle wall and the corpus luteum. The distribution of the lipids, like that of phosphatase, is known to be different in various species. Perhaps the phosphatase takes part in the metabolism of phospholipids. If this guess is correct, the puzzling variety in the distribution of phosphatase in the follicles and corpora lutea of different species, observed by Gomori and confirmed here, may ultimately lead to an explanation of the function of the enzyme in such cells as these, for it offers the possibility of tracing an association between phosphatase and one or another of the various intracellular lipids.

As mentioned above, in the ovary of the sow the theca interna is very sharply distinguishable under the microscope by Gomori's method. This fact has permitted following the fate of the theca cells in an ample series of sows' corpora lutea from ovulation to mid-pregnancy. The present writer,[2] describing the formation of the corpus luteum of the sow as revealed by ordinary histological stains, stated that as the corpus luteum is organized from the collapsed follicle wall, theca interna cells become scattered among the lutein cells derived from the granulosa and are thus more or less disseminated throughout the fully formed corpus luteum. This interpretation was challenged by Solomons and Gatenby,[3] but it is completely confirmed by the Gomori preparations. At the 18th day of pregnancy, for example, the corpus luteum of the sow is made up of phosphatase-free granulosa lutein cells interspersed with phosphatase-laden theca interna cells. Later in pregnancy the granulosa lutein cells also acquire cytoplasmic phosphatase and the picture becomes less clear.

A detailed account with illustrations will be published later.

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[2] G. W. Corner, *Am. Jour. Anat.*, 26: 117–183, 1919.
[3] B. Solomons and J. B. Gatenby, *Jour. Obstet. Gynec. Brit. Emp.*, n.s. 31: 580–594, 1924.

ABSENCE OF GLUCOSE EFFECT ON GASTRO-INTESTINAL PHOSPHATE ABSORPTION

SINCE the fundamental experiments of Cori,[1] the mechanism by which glucose is absorbed from the digestive system has received considerable attention.[2,3] Primarily from the experiments with phoridzin,[4] evidence indicated a mechanism involving the coupling of phosphate forming fructose 1–6 phosphate. By the use of tagged (radioactive) ions we made an attempt to determine the relative permeability of the gastro-intestinal wall to phosphate in the presence of glucose as compared with control solutions.

Radioactive phosphate, $_{15}P^{32}$, with a half-life of 14.2 days, was supplied by the Radiation Laboratory of the UNIVERSITY of California in the form of a phosphate solution of pH 7.35 and whose concentration calculated as Na_2HPO_4 was 0.105M and with an activity of 78 μC/cc. The method of preparation of the phosphate as well as the description of the Geiger-Müller counter has been previously given by Brooks.[5]

METHOD

Laboratory rats were placed on a wire screen without food for two days to insure a comparatively empty gastro-intestinal tract. Experimentally 0.4 cc of the radioactive phosphate diluted with 4.6 cc isotonic glucose was fed by stomach tube. Isotonic NaCl or Ringer's was substituted for glucose in the control group. Ten minutes after feeding the animals were killed by decapitation and quickly autopsied. Small portions of the fundus of the stomach, mid-part of duodenum and jejunum, and the upper and mid-portion of the ileum (Ileum I and II of the table) were excised. The sections were uniformly washed with isotonic glucose just enough to remove the unabsorbed and organic material, dried with filter paper and weighed. A determi-

[1] C. F. Cori, *Jour. Biol. Chem.*, 66: 691, 1925.
[2] W. Wilbrandt and L. Laszt, *Biochem. Zeitschr.*, 259: 398, 1933.
[3] L. V. Beck, *Am. Jour. Physiol.*, 133: p. 210, 1941.
[4] S. Rapaport, N. Nelson, G. M. Guest and I. A. Mirsky, SCIENCE, 93: 88, 1941.
[5] S. C. Brooks, *Biol. Bull.*, 84: 213, 1943.

TABLE 1

PHOSPHATE CONTENT OF FRESH EXCISED TISSUES OF RATS KILLED 10 MINUTES AFTER FEEDING SOLUTIONS CONTAINING 22.3×10^{-3} mM/1 OF RADIOPHOSPHATE

Tissue	Radiophosphate found, mM/L. $\times 10^{-3}$. Isotonic diluents								Means	
	NaCl	Ringer	Ringer	Ringer	Ringer	Ringer	Glucose	Glucose	Controls	Glucose
Stomach	1.00	...	1.76	0.64	0.91	0.90	1.17	1.15	1.04	1.16
Duodenum	5.06	2.36	9.70	4.63	0.93	4.44	3.71	2.83	4.52	3.27
Jejunum	8.63	3.25	...	2.91	3.14	6.54	5.33	4.30	4.89	4.81
Ileum I	2.06	4.07	2.84	4.69	1.01	4.20	6.43	5.67	3.14	6.05
Ileum II	...	1.90	0.77	2.21	0.35	1.89	...	...	1.42	...

nation, by use of the Geiger-Müller counter, was then made of the absorbed amount of radioactive phosphate per gram weight of tissue and calculated to millimoles per liter of absorbed phosphate. Since the absorption of radiation by wet tissue is not great, it was felt that in these preliminary experiments ashing might be omitted.

Individual variations proved to be high. Stomach and intestinal contents varied to a marked degree, although all had been deprived of food for the same period of time. While no effect of glucose on the uptake of phosphate was found, the small number of experiments is not decisive but leads to the tentative conclusion that if the permeability of the gastro-intestinal tract to inorganic phosphate is affected by glucose, the effect is small, probably within 30 per cent. The finding of Erf, Tuttle and Scott,[6] who found that phosphate absorption was significantly increased in mice over a three-day period, relates to the utilization within the epithelial cells, and consequently to the intake of phosphate, but without any necessary increase in permeability of these cells to phosphate.

CONCLUSION

It is tentatively concluded that the presence and the presumable absorption of glucose has no important effect on the permeability of gastro-intestinal cells to phosphate.

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ANTIGENIC DIFFERENCES BETWEEN THE SPERM OF DIFFERENT INBRED STRAINS OF MICE[1]

EVIDENCE has been obtained of the presence in the sperm of C57 strain and P strain mice of antigens lacking in the sperm of B alb C (Bagg albino) strain mice. The procedure followed is essentially the same as one of the common procedures for the demonstration of blood groups in experimental animals, namely, the injection of cells from individuals of one group or antigenic type into individuals of the same species but of a different group or antigenic type, followed by agglutination tests with the resulting antisera against the injected cells. However, to adapt this method to spermatozoa, two modifications of the blood cell technique are necessary. First, because sperm agglutinins are formed even when sperm are injected into the male producing them,[2] it is necessary to absorb all antisera with sperm of some type other than that against which they are to be tested. Second, because one male does not yield nearly enough sperm for the injections and absorptions, pooling of the sperm of a number of males of the same sperm type is necessary. This is possible in the case of mice because of the existence of numerous inbred stocks all spermatozoa from any one of which may be presumed to be genetically and immunologically identical.

Sperm for injections and absorptions were obtained by killing male mice, dissecting out the vasa deferentia and epididymides, mincing these in Locke's in a watch glass with fine scissors, straining through two fine wire strainers into a filter flask, centrifuging to remove excess fluid, and resuspending in the amount of Locke's desired for injection or in the serum to be absorbed. The mice injected were in every case B alb C females. The sperm used for injection were in most cases from C57 males, in one case from F_1 hybrid males between the C57 black and P strains. The sperm used for absorption were usually B alb C, with a control on the adequacy of the absorption procedure usually provided by a parallel absorption with C57 or F_1 sperm. Injections, varying in different series from about 10,000,000 to 30,000,000 sperm each, were made intraperitoneally in courses of 3 injections on consecutive days followed by 4 days' rest. The number of courses varied from 4 to 7. Animals were killed 7 to 14 days after the last injec-

[6] L. A. Erf, L. W. Tuttle and K. G. Scott, *Proc. Soc. Exp. Biol. and Med.*, 45: 652, 1940.

[1] This investigation has been aided by a grant to the Roscoe B. Jackson Memorial Laboratory from the National Cancer Institute. The writer also takes pleasure in acknowledging the valuable assistance of Miss Helen Poucher and Miss Carol Joos.

[2] S. Metalnikoff, *Ann. Inst. Pasteur*, 14: 577, 1900.

tion. The initial titer of the antisera ranged from 1 : 24 to 1 : 512, but in some cases these antisera were diluted 1 in 6 or more prior to absorption. Absorptions at first were performed for an hour or more at room temperature, followed by a period of varying length (usually over night) in the refrigerator, later for one half hour at room temperature. Two absorptions were sometimes necessary. Agglutination tests were run in hanging drops or in small vials, readings in every case being made under the microscope at from 15 to 30 minutes after the addition of sperm to the antisera. Agglutinations were classified as 0, ±, +, ++, +++, or ++++, the latter indicating that all or nearly all the motile sperm were struck together in mats or clumps. Adhesion was usually by tails or middle-pieces, but it was not uncommon to see active sperm pairs accurately aligned and closely adherent throughout their lengths, and in a few cases adhesion was almost exclusively by heads. There was no indication of any effect on motility.

Of 9 antisera tested, 4 have given positive results, 4 have given negative results, and 1 has given doubtful results. The results with 3 of the 4 positive sera are summarized in Table 1. It will be seen that anti-C57

TABLE 1

Sperm injected	Sperm absorbed with	Sperm tested against			
		F_1(C57 × P)	C57	C	P
C57	C57		0		
Same	C		++++	±	
C57	C		++++	+	+++
F_1(C57 × P)	C	+++	++++	+	+++
Same	C57	+++	±	±	++
Control	C		0	0	0

sperm serum absorbed with C sperm clearly differentiates between C57 and C sperm, strongly agglutinating the former, but leaving the latter largely free swimming. Whether one or more antigens is involved is not yet clear. The results with anti-F_1(C57 × P) sperm serum point to the presence of a second distinguishing antigen or group of antigens in the P sperm.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A CLOSED CELL FOR ELECTRON MICROSCOPY

ONE of the severest disabilities of the electron microscope has consisted in the fact that the specimen is exposed to high vacuum and consequently is completely desiccated and perhaps destroyed before observation. For many purposes it is desirable to study a specimen in its original medium without such desiccation and possible alteration. For this purpose an enclosed chamber is necessary.

A very simple closed chamber for electron microscopy has here been devised. The plastic windows interfere very little with electron examination, and they are liquid and vapor tight and easily withstand a difference of one atmosphere pressure between the inside of the cell and the remainder of the electron microscope. A fuller account is being communicated to *The Journal of Applied Physics.*

The cell[1] is shown in Fig. 1. It consists of two circular discs of platinum one eighth inch in diameter. The large annular groove in the lower disc holds a ring of adhesive wax (Cenco "Tackiwax") and excess liquid from the specimen. When the protruding annular ridge of the cover is pressed down upon this, the wax forms a vacuum-tight seal. Before the two discs are pressed together it is necessary to place a thin collodion film upon each. Ordinary collodion films are worthless, but the following procedure yields strong vapor-tight membranes about 500 Ångstroms thick.

Two drops of a 1 per cent. solution or one drop of a 2 per cent. solution of Baker U.S.P. collodion cotton in purified amyl acetate is allowed to spread on thoroughly cleaned mercury, nine centimeters square. The mercury is previously washed three or four times in a long column of 10 per cent. potassium hydroxide, followed by washings with 1N nitric acid, hot and cold water, and finally drying. Mercury and film are kept as free as possible from dust. The average thickness of films is less than six hundred Ångstroms. A rough indication of the film strength can be obtained by puncturing the film with a sharp point. If the point passes through without encountering any resistance, the film is weak; if it is stopped momentarily with wrinkles radiating out from the point of contact, then the film is relatively strong.

To place the films as a window covering a 0.1 millimeter hole, a centrally bored platinum disc is simply raised upward through the surface of the mercury. Scoring the film beforehand with a sharp needle facilitates its removal.

Contrast in a liquid medium is necessarily far less, although the membranes still permit sharp photographs of dry colloidal gold particles. Likewise, for

[1] The cells, together with jigs and supports used with them, are supplied by Mr. J. Grebmeier, Instrument Maker, Menlo Park, Calif. They fit existing RCA microscopes. An alternative mechanical seal avoids wax which melts.

ultramicroscopic particles, free Brownian movement in a liquid as fluid as water is far too large and rapid to permit of photographic recording.

We are indebted to Dr. L. Marton, of Stanford University, and Dr. Otto Beeck and Mr. A. E. Smith, of the shell Development Company, Emeryville, for their very generous cooperation in operating the Stanford microscope and the Berkeley R.C.A. microscope, respectively. Without this, our work could not have been carried out.

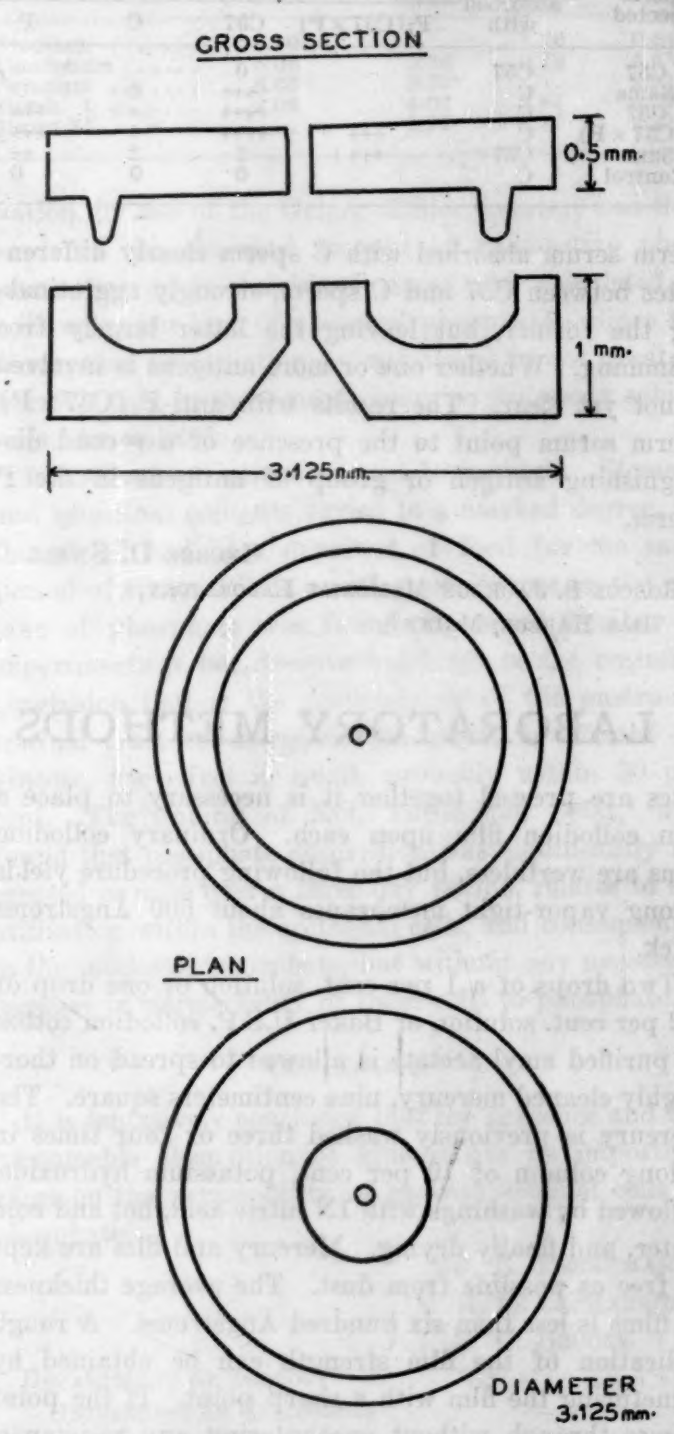

FIG. 1. Perforated platinum discs used to form enclosed electron microscope cell; cell and cover shown in cross section and in plan.

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A METHOD FOR CENTRIFUGING AT LOW TEMPERATURE

THE laboratory centrifuge is often employed in the preparation of many biological materials. In a good many cases, especially in enzyme work, it is desirable or necessary to centrifuge at a low temperature. We have adapted a Type 1-SB International Centrifuge to run at a low temperature as described below. The centrifuge is in no way impaired for other regular uses.

The drain in the bottom of the centrifuge case is plugged with a rubber stopper, and small pieces of dry ice are placed on the bottom of the case. The amount of dry ice is determined by the length of time of centrifuging. A 17-inch circle of sheet metal with a 5-inch center hole is inserted in the case and is lodged tightly on the bottom of the case over the dry ice by tamping the metal circle along the outer edge. The centrifuge head is placed in position and the centrifuge is ready for use. It is desirable but not necessary to obtain partial insulation of the centrifuge by covering with several layers of cloth.

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